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THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. VI. ANN ARBOR, MARCH, 1890. No. 11.

ORIGINAL ARTICLES.

THEORY OF STORMS, BASED ON REDFIELD'S LAWS.

BY M. FAYE, MEMBRE DE L'INSTITUT, PRESIDENT DU BUREAU DES LONGITUDES, ETC.

[CONCLUDED.*]

7. *Progressive Changes of the Form of Cyclones.*—The constitution, described in the preceding part of this paper, becomes modified little by little as a cyclone leaves its place of origin. Like all whirls, they tend to become enlarged or to extend themselves. Their diameter, at first from one to two degrees, becomes successively three, four and five degrees or more. Their velocity of one meter per second near the equator rises to four or five near the tropics, and to eight, ten and even fifteen meters,—that of an express train,—in temperate climates. Hence the modifications which we are to study.

In the first place, the spirals of a cyclone arising in the upper current require a certain time to descend to the earth. The whirl as a whole advances during this time, and the upper spirals will take the lead over the lower ones; consequently the central line of these spirals inclines toward the horizon in the direction of the advance. But the spirals will remain parallel

*In the next number we begin M. Faye's Discussion of Tornadoes.

to the surface of the earth, or in other words, their axis of gyration, at first coinciding with the axis of the cyclone, which is sensibly vertical, will separate, though remaining vertical. The circular gyrations then become a little dispersed, in the direction of movement, without change of form.

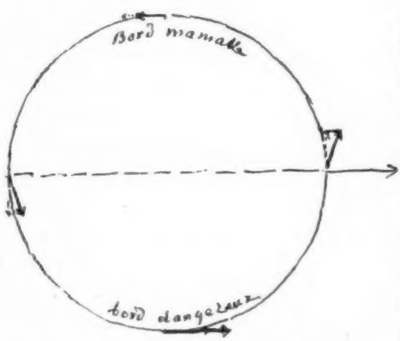
Let us now consider the barometric depression which is produced under a cyclone. It results from the pressure, at some elevation, of the rapid gyrations which modify below them the vertical transmission of pressure. When these circular spirals are ranged regularly one above the other, as in the lower latitudes, the isobars are themselves circular and concentric about the calm center. But as the spirals become dispersed along the trajectory, the barometric depression is modified and the isobars become elongated, becoming non-concentric ovals. The wind arrows are now no longer exactly parallel to them. Observe that these phenomena are reproduced, as we will see further on, in *trombes* and tornadoes, of which the inclination toward the earth is often considerable, although their spirals are always parallel to the horizon, like those of cyclones.*

Another sort of deformation is produced when the velocity of translation of the storm has become stronger. Very near the equator, with a velocity of a meter or two per second, this movement is so feeble that there is no distinction between the manageable part and the dangerous part of a hurricane. But in the temperate zone where the velocity of translation attains 10 m. and even 15 m. per second,—that is, the velocity of an express train,—the linear velocity of gyration of the circular spirals is increased from 11 m. or 15 m. upon the right, while it is diminished by the same amount on the left. A difference of 20 m. to 30 m. is considerable, and thoroughly justifies the distinction made by navigators between the manageable part and the dangerous part of a storm. Everywhere the velocity of translation is compounded with that of gyration, changing both the intensity and the direction of the wind. Figure 4 shows that this alters but little the form of the

* It may now be seen why, in cyclones inclined to the horizon, the central vista is no longer seen in the zenith, or is not so striking as in the cyclones of the tropics.

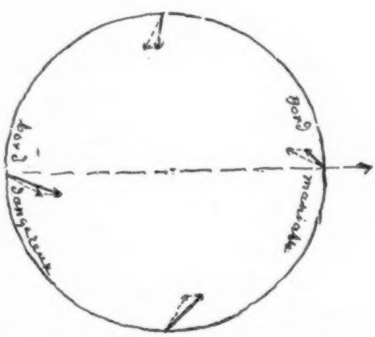
spirals upon the borders of the tempest and is almost insensible upon the spirals nearer the center.

fig. 4



I cannot help remarking here, with Dr. Sprung (p. 245 of his treatise), how different the preceding effects are when they are studied on the diagrams of meteorologists. Figure 5, which I borrow of him, shows that in this case the manageable part, instead of being at the left of the cyclone is at the front, while the dangerous quarter, instead of being at the right (in the northern hemisphere) is behind. This alone would suffice to condemn these diagrams. Figure 4, on the contrary, constructed for Redfield's circular spirals, is in accord with the daily experience of navigators. I regret that Dr. Sprung did not construct it, and place it opposite the first.

fig 5



Finally, cyclones, on account of changes in their generating currents, have a tendency to divide into segments. During this work of segmentation, which is seen only in high latitudes, the ordinary rules undergo a momentary eclipse, to reappear as soon as the segmentation is complete, when they apply again to the partial cyclones, now become independent.

8. *Interpretation of Synoptic Charts.*—Eminent meteoro-

logists, without consenting to examine the preceding theory, have limited themselves to saying that a glance at the synoptic charts proves that around a depression—a *low*—, the arrows of the wind are more or less inclined toward the isobars, and indicate thus a centripetal component. In order that the air should move thus, more or less directly toward a central region, it must take an ascending direction in that region, incompatible with my ideas. This objection is based upon a mistake, which is very compromising for the science of meteorology.

In all treatises upon this subject the winds are considered as being determined exclusively by differences of barometric pressure. The wind blows from the region where the pressure is greatest, toward the region where a rarefaction of air has been produced. In other words, winds are aspiration currents. This is what is mean by the expression—*every wind has its cause ahead of it.*

If the distribution of pressure on the surface of the globe be represented graphically by isobaric lines, these lines are like the curves of level on an undulating surface. The water which flows on this surface, to obey the laws of gravity, will follow a trajectory normal to these curves of level. Similarly, air, in flowing from a given isobar towards a lower isobar, should follow trajectories perpendicular to these curves with a velocity inversely proportional to their distance apart.

The direction of the wind is modified by the diurnal rotation of the globe, which constantly turns toward the right the air which is in motion, the more the nearer the region under consideration is to the pole. Very near the equator this deviation is insensible.

If the barometric depression, the cause of the movement, constitutes a local minimum, the isobars will be curved around it and the winds blowing everywhere in the direction perpendicular to these isobars will evidently cause a centripetal influx. For a barometric maximum the isobars will still be curves concentric to this maximum, but the winds will blow from the center towards the boundary following divergent directions.

Synoptic charts are full of examples of this sort which de-

pend principally on the distribution of temperature, humidity, on the conformation of the surface, etc. M. L. Teisserenc de Bort has shown this dependence plainly in a work cited by Dr. Sprung in his recent treatise on meteorology. The first figure in this treatise represents the distribution of temperature in summer, at a given moment, on the Spanish peninsula. The isotherms indicate a maximum in the vicinity of Madrid. Around this point, the temperature decreases toward the two seas. For the same moment the second figure, which gives the isobars and the arrows of the wind, shows a depression in the center. The isobars are concave almost everywhere around this point, toward which the arrows of the wind would be directed normally to the isobars, were they not sensibly deviated by the diurnal rotation of the globe and by the conformation of the surface.

On the other hand, in January, a minimum of temperature is found in the heart of Spain; the isobars, at the same moment, indicate a maximum of pressure in that region, and the winds diverge with deviations analagous to the preceding.

Temperature and humidity vary continually, in any region with the action of the sun, the winds, etc., and the minima and maxima are deformed continually and displaced in very variable directions,—the minima especially, while the maxima may remain, at times, in the same place for weeks at a time. A glance at the synoptic charts suffices to show these continual variations by the disposition of the isobars, and by the evident convergence of the arrows of the wind toward a *low*, or by their divergence around a *high*.

The method of monthly means has been even applied to these phenomena. For each place of observation has been taken the mean barometric heights observed in January, for example; then by the aid of these data, have been traced the isobaric lines over the entire globe. A very marked maximum is then found over central Asia and another over the north of America; while the minima are over the oceans; on the Pacific ocean, for example, a little south of Behring's Straits, and another on the Atlantic, southwest of Iceland.

In the month of July there is a complete reversal. Maxima are established, one in the North Pacific, the other in the Atlantic west of the Azores, while the minima choose a domicile upon the continents, in the United States and in the center of Asia. Naturally, analagous phenomena are produced, *mutatis mutandis*, on the southern hemisphere.

There are two observations to be made. The first is that the question is that of *means*. At a given instant in July, for example, there may be to the west of the Azores not a maximum, but a well characterized minimum. The only assured fact is, that in July the sum of the maxima is greater than that of the minima. The second observation is that in these oscillatory displacements of maxima or of minima there can be no question of trajectories.

These purely statical considerations, of a secondary interest, would never have played a great rôle, if meteorologists, under the dominion of a preconceived idea, had not persuaded themselves that cyclones are only depressions like other storms, and are only marked by an exceptional violence for their interior winds. They would never understand, in spite of the discoveries of Redfield and of his successors, that there are distinct systems of winds in which the air, instead of progressing toward the center of a depression, whirls around this center parallel to the isobars,—systems where the central depression has an entirely different course from that in the ordinary minima,—systems which travel with great velocity while preserving their form, without regard to seasons, or to the distribution of temperatures, without regard to the conformation of the surface, to the prevailing winds or climates;—that is, without regard to all that determines purely statical depressions.

The argument drawn from the synoptic charts is explained thus: That in the ordinary depressions, the wind arrows are directed more or less towards the center, may be seen effectively on the synoptic charts, and as they are much more frequent than the storms with which they are confounded (although everything separates them except the arrangement of the isobars), it is affirmed that a glance over the chart suffices to

justify an assertion at which one could not but be astonished. It is very desirable, in order to avoid this mistake in future, that two different modes of tracing charts be adopted, to distinguish between cyclones and purely statical depressions. It is also necessary to determine the real limits of each storm, that is, the circle ABCD of the figure 3, p. 411, for it is there only that one can study the existing relations between isobars and arrows of the wind.

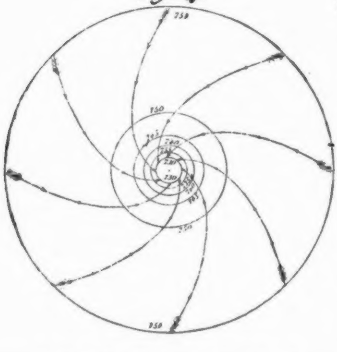
8. *Short Historical Notes.* — 1st. The gyratory motion. Since tempests have been attributed to simple depressions toward which the air moves to fill a vacuum, there has been no place left for gyrations; there are only centripetal movements. This is the thesis that Espy, more than fifty years ago, defended against Redfield. Espy thought he spoke in the name of science. Redfield, intimidated perhaps by the assurance of his antagonist, ended by conceding that, in cyclones, there might be some traces of centripetal motion. To-day meteorologists still take the side of Espy, but add to it a fact which this celebrated student neglected, a circumstance capable of causing a trace of gyration in the direction in which it is really produced, that is the diurnal rotation of the earth. They say that the truth lies absolutely neither with one side nor the other, but between the two. That seems to me a supreme injustice to Redfield. The feeble and slow diurnal rotation is incapable of producing the large and powerful gyrations of storms. In ordinary movements of air, that is, those which are due to simple differences of pressure, there is no more resistance to the right than to the left. The least deviating force would have its plain and complete effect, except for the conformations of the surface.* This deflection is towards the right; it is proportional to the sine of the latitude, and consequently becomes insensible near the equator—precisely where the gyration of Redfield is most clearly

*It is quite different with gyratory movements. This influence can, in this case, be compared with that which is exercised upon a train of a circular railroad; this is evidently a very slight augmentation of the pressure on the rails produced by centrifugal force. This last force being, in this case, whirling motion, counterbalanced by external atmospheric pressure, there will result an imperceptible dilatation of the spirals, of which it is not necessary to take notice.

characterized. We shall see further on that it is everywhere insufficient.

Passing over this irrefutable objection, it has been found that the effect produced upon the winds, directed towards an ordinary depression, causes them to describe logarithmic spirals. These curves cut the radii vectores at a constant angle, that is the angle of deviation, at least if circular isobars be assumed. In fact these curves reach the center only after an infinite number of revolutions, but this difficulty is eluded by arresting all these spirals at an inner circle inclosing the minimum. If we neglect the feeble ascending movement of the air which operates above a minimum of this sort, it may be admitted that this is what takes place in a purely statical depression such as has been discussed above.

fig. 6



Let us consider the diagram Figure 6, taken from an article in the English Journal, *Nature*, of June 14, 1888. At first it seems as if the author wished to represent the course of the winds in one of the *lows*. It is nothing of the kind; it relates to cyclones. It is a question of giving *le coup de la mort*, the death-blow, to the laws of storms, to the discoveries of Redfield, to Piddington's rule of eight points, and of proving to navigators that in the tropical regions, to recognize the center of a storm, it is necessary, when the direction of the wind has been determined, to add, not 90° to the azimuth of the latter, but only 27° 48′, that is, two and half points instead of eight. The author thinks that he thus represents the Manilla cyclone of October 20, 1882, already cited in connection with the central calm. The author has taken pains to represent this region by a small circle in the middle of his drawing.

What becomes of the violent gyrations of storms, on this diagram? The air does not make there even a quarter turn.

Storms thus constituted merit no longer the name of cyclone; they should be called centripetal storms. An unfortunate ship, disabled by the violence of winds and waves, reduced to a wreck, will no longer risk, as has happened, being drawn on by furious gyrations, to make several turns around the center; it will be pushed almost directly into the region of calm, and will be unable to leave it. The furious winds which approach this region on all sides, at an angle of 62° 12′, should stop here sharply as if the central calm were protected by a wall of brass.

Other masters of this subject do not go so far; they content themselves by taking two or three points from Piddington's rule. They recognize that a quarter of a circle does not constitute a gyration, and that at least in tropical regions the air executes a great number of turns around the center, and finishes by approaching the region of calm tangentially. These are concessions which should be acknowledged, if they did not, at the same time, maintain as firmly as their predecessors the hypothesis of aspiration and an ascending motion in the midst of a cyclone. In this hypothesis there is no other possible source of gyration than the slow diurnal movement of the earth, and that evidently does not suffice to explain the furious gyrations which cover the surface over a territory sometimes almost as great as France, and which are constantly renewing themselves and expending an enormous amount of energy.

One of the masters of the science denied beforehand an ingenious comparison. If, in a large basin, of which the bottom is covered with a few centimeters of water, a motion of rotation as slow as the terrestrial rotation around the vertical of place, is communicated to the water, and if at the same time a small orifice at the bottom of the basin is opened, the water on escaping or emerging torward the orifice will take a whirling motion around it. This is quite true, but the sum of the areas described by the radii vectores of all the molecules remains constant, and can in no case exceed the original sum.

Moreover, if it is a whirl in water, the bottom of the basin and the orifice are of necessity fixed, so that the gyrations may become accelerated around the orifice. When it is an air-whirl,

whether it tends to rise by an excess of temperature, or is aspired by rarefaction, there must be, to produce the same result a little above the surface, a stratum as large at least as the base of the cyclone, pierced by a central orifice. It is enough to state this condition, to show that the conception mentioned, is inadmissable. It is known besides that the central column of air in a storm is descending and not ascending.

These difficulties do not exist in the present theory, where the gyration has its origin in the upper currents, at the expense of the inequalities of velocity, for these inequalities collected in a vast mouth are always comparable in energy to the gyrations perceived by us at the surface of the earth.

2nd. On the movement of translation, the same results as for gyrations, the same impossibility of accounting for their grandiose movements by the theory of meteorologists. To be assured of it, it suffices to glance through the twenty-seven pages (244–270) that Dr. Sprung has devoted to this important subject in his learned treatise, which is the most considerable effort recently made to save the theory from a decisive check. Chapter five, on the movement of translation of atmospheric whirls, opens as follows:

"In what does the movement of translation of an atmospheric whirl consist? Experience teaches us that the hypothesis, to which we have held until now, of a stationary system of winds is exceptional. We must then examine as to how the movement of translation by which it is animated really modifies the relation between pressures, the movement of the air, etc., to which we have come in our hypothesis."

Dr. Sprung encounters in this examination such contradictions of facts, that he is obliged to change entirely his idea of the nature of cyclones, and to prepare as a sort of fundamental theorem, that

"In the lower strata of the atmosphere a cyclone is not propagated as would be a mass of air animated by a movement of rotation, but like a wave into which new masses of air continually come into action."

One of these hypotheses is as inadmissable as the other, and

the author after having discussed all the works of recent meteorologists arrives at this admission:

"None of the principles used up to this time can account for the movement of translation of cyclones."

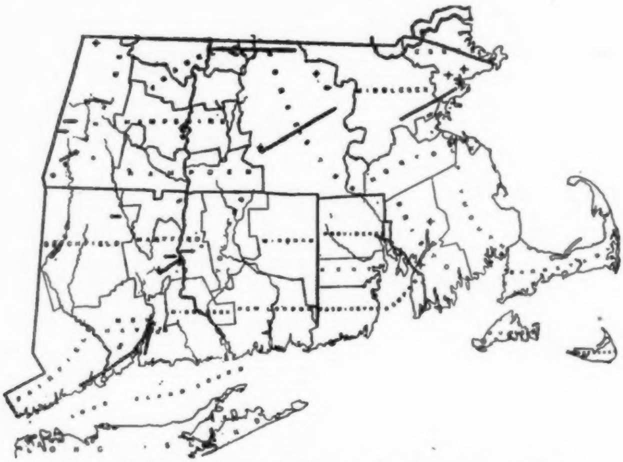
I regret that Dr. Sprung has not given to the theory which I have just explained, sufficient attention to enable it to have a place in this discussion. His conclusion would have been, I venture to believe, quite different. This acknowledged impotence of the hypothesis of the meteorologists to account for the essential characteristics of storms, might be considered as a decisive proof against the hypothesis.

Theoretical Conclusion.—Cyclones are descending whirls with a vertical axis, originate in the upper currents of the atmosphere, and follow the course of these currents.

Consequently the trajectory of each cyclone is the projection upon the surface of the generating current.

The laws of storms are admirable laws of nature, and begin to deviate a little from the facts only in the regions where cyclones themselves commence to change, as a result of their excessive size and of their increasing velocity.

Practical Conclusion.—Piddington's rule of eight points should be recommended to navigators. The correction of two or three points, which it has been proposed to apply to them is without reason. Those which arise from the modifications which a cyclone undergoes in passing into high latitudes should be studied by means of observations made at sea, on coasts, or in observatories sufficiently elevated above the ordinary accidents of the surface. It is indispensable in this study not to confound cyclones with depressions which are purely statical to which the laws of tempests do not in any way apply.



TORNADOES IN MASSACHUSETTS, RHODE ISLAND AND CONNECTICUT.

STATE TORNADO CHARTS.—MASSACHUSETTS.

By Lieut. Jno. P. Finley, Signal Service, U. S. A.

Table I.—*Tornadoes in Massachusetts.*

Period of observation, 80 years, 1809–1888.

Total number of storms,—25.

Year of greatest frequency, 1879,—4 storms.

Average yearly frequency,—1.6 storms.

Year in past (10) ten years, no report of storms,—1880, 1881, 1882, 1884 and 1887.

Month of greatest frequency, July,—10 storms.

Day of greatest frequency, July 16th,—4 storms.

Hour of greatest frequency, 4 to 5 p. m.

Months without storms, January, February, March, April, October, November and December.

Prevailing direction of storm movement, NE.

Region of maximum storm frequency, extreme west and northeast portions.

TABLE II.—*A Chronological Table showing the location, date and time of occurrence and general character of formation and movement of Tornadoes in the State of Massachusetts, for a period of 80 years, from 1809 to 1888.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Berkshire		1809		E.	Funnel.	2,640.
Suffolk	September 23.	1815	Afternoon.	NE.		Narrow.
Berkshire		1815		E	Funnel.	
Essex	August 1.	1815	Afternoon.	NE.		
Essex	"	1815	"	NE.		
Franklin	September 9.	1821	6 p. m.	E.	Inverted cone.	16 to 166.
Essex	June 30.	1841	3 p. m.	SE.		5,280.
Middlesex	August 22.	1851	4 p. m.	ENE.	Inverted cone.	660 to 1,254.
Middlesex	May 4.	1852	11 a. m.	Easterly	Funnel.	60 to 100.
Worcester	June 11.	1871	4:10 p. m.	NE.		700 to 1,320.
Essex		1872	Afternoon.	NE.		
	September 4.	1873				
Hampshire	June 14	1877	Afternoon.	NE.		
Bristol	August 29.	1877	4:30 p. m.			
Hampshire	July 21.	1878	Afternoon.			
Franklin	August 9.	1878	6 p. m.	ESE.		33 to 160.
Hampshire	July 16.	1879	3 p. m.			
Berkshire	"	1879	2:30 p. m.	SE.		800 to 1,000.
Bristol	"	1879	5:30 p. m.			
Worcester	"	1879	3:35 p. m.	NE.	Funnel.	
Berkshire	July 2.	1883	5 p. m.			
Worcester	July 9.	1885	4:35 p. m	NE.	Funnel.	
Berkshire	July 30.	1886	Afternoon.	NE.	"	
Worcester	"	1886	"	E.		
Suffolk	July 11.	1888	12:15 a. m.	E 13° N	Funnel.	100 to 500.

TABLE III.—*Relative frequency of Tornadoes by months and days, for Massachusetts.*

The index figures to the right and above the dates show how many times tornadoes occurred on that day of the month.

Month.	Day of Month.	No. of Days.	Total No. of Tornadoes per month.
May	4	1	1
June	11, 14 and 30	3	3
July	2, 9, 11, (16)^{4}, 21 and (30)^{2}	6	10
August	(1)^{2}. 9, 22 and 29	4	5
September	4, 9 and 23	2	3
(—) Blank	(—)^{3}	1	3
Total		17	25

NOTE.—The blank (—) signifies date missing.

STATE TORNADO CHARTS.—RHODE ISLAND AND CONNECTICUT.

BY LIEUT. JNO. P. FINLEY, SIGNAL SERVICE, U. S. A.

TABLE I.—*Tornadoes in Rhode Island.*

Period of observation, 51 years, 1838-1888.

Total number of storms,—1.

Year of greatest frequency, none

Average yearly frequency, none.

Year in past ten (10) years, no report of storms,—1879 to 1888 inclusive

Month of greatest frequency, none.

Day of greatest frequency, none.

Hour of greatest frequency, none.

Months without storms,—January to July inclusive, and September to December inclusive.

Prevailing direction of storm movement, none.

Region of maximum storm frequency, none.

TABLE I.—*Tornadoes in Connecticut.*

Period of observation, 207 years, 1682-1888.

Total number of storms,—13.

Year of greatest frequency, 1886,—2 storms.

Average yearly frequency, 0.7 storms.

Year in past ten (10) years, no report of storms,—1879, 1881, 1883, 1884, 1887, and 1888.

Months of greatest frequency, July and August,—3 storms each.

Day of greatest frequency,—no day having more than one storm.

Hours of greatest frequency, 5 to 7 P. M.

Months without storms,—January, February, March, April, November and December.

Prevailing direction of storm movement, NE.

Region of maximum storm frequency, southern portion.

TABLE II.—*A Chronological Table, showing the location, date and time of occurrence, and general character of formation and movement of Tornadoes in the State of Rhode Island for a period of 51 years, from 1838 to 1888.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Providence	August 30.	1838	4 p. m.	ESE.	Inverted cone.	330 to 412

TABLE III.—*Relative frequency of Tornadoes by months and days, for Rhode Island.*

Month.	Day of Month.	No. of Days.	Total No. of Tornadoes per month.
August	30	1	1
Total		1	1

TABLE II.—*A Chronological Table, showing the location, date and time of occurrence, and general character of formation and movement of Tornadoes in the State of Connecticut for a period of 207 years, from 1682 to 1888.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
New Haven and Fairfield	June 10.	1682	2:30 p. m.	E.		2,640.
Hartford		1728 or 1729		NE.		
Hartford	August 20.	1787	3 p. m.	NE.	Funnel.	495 to 990.
New Haven	June 19.	1794	4 p. m.	NE.		100 to 350.
New Haven	October 7.	1797	6:30 p. m.			
New Haven	July 31.	1839	11:30 a. m.	NE.	Funnel.	330 to 495.
New Haven	August 13.	1840	Afternoon.	NE.		
New Haven	August 9.	1878	6:15 p. m.	ESE.	Funnel.	600 to 1 200.
Hartford	May 29.	1880	1:30 p. m.	NE.	"	2.000 to 5,280.
Litchfield	September 14	1882		E.		50.
Hartford	July 9.	1885	5:30 p. m.	E.	Funnel.	
Hartford	July 30.	1886	5 p m.	ESE.		
Hartford and Tollard	September 12.	1886	7 p. m.	N 30° E.	Basket.	160 to 330.

TABLE III.—*Relative frequency of Tornadoes by months and days, for Connecticut.*

The index figures to the right and above the dates show how many times tornadoes occurred on that day of the month.

Month.	Day of Month.	No. of Days.	Total No. of Tornadoes per month.
May	29	1	1
June	10 and 19	2	2
July	9, 30 and 31	3	3
August	9, 13 and 20	3	3
September	12 and 14	2	2
October	7	1	1
(—) Blank	(—)	1	1
Total		13	13

NOTE.—The (—) signifies date missing

THE STORM OF NOVEMBER 7-12, 1888.

BY A. H. DUTTON.

The great extent and the location of the area within which the influence of this storm was felt and the general damage it caused, have attracted so much attention that it is thought the following brief description of its progress will be of interest. It must not be thought, however, that the violence of the storm was unusual for this season of the year.

On November 7th, an area of low barometer, which had swept across the United States from the state of Kansas, was central over the straits of Belle Isle. Low barometer prevailed to the eastward, while in its rear was an area of high. The conditions were thus favorable to rapid translatory motion from west to east, and, on the 8th, the storm center had reached the 40th meridian, rapidly increasing in energy. The isobars and wind directions about noon on this day show great irregularity, especially south of the center; this was possibly due, to some extent, to the influence of another storm, which prevailed from the 6th to 8th inclusive, between the trade-wind belt and the 40th parallel, about the longitude of 50° west.

During the night of the 8th, and throughout the 9th, the influence of the storm was felt over the entire region east of the Grand Banks, and north of the 25th parallel. The enormous precipitation over this great area caused the depression to deepen rapidly, and the storm to increase in fury. The wind blew with full hurricane force in many places, with heavy seas. St. Elmo's fire and other electric phenomena were observed in several instances. Fortunately for west-bound steamers, the storm moved nearly due north on the night of the 9th, but during the forenoon of the 11th recurved to the south and east. One effect of this irregular movement was the rough cross sea experienced, during the 11th and 12th, along the transatlantic routes east of the 30th meridian. At noon on the latter date the storm was central in latitude 51° north, longitude 17° west, the pressure having fallen very low: one reliable report shows a corrected barometer reading of 28.20, at 3 A. M., in latitude 50° 29′ N, longitude 19° 10′ W. This occurred in the calm area at the center.

On the 13th the depression moved about NNE, along the Irish coast, with marked loss of energy, and disappeared north of the British Isles.

No correct estimate can yet be made of the great damage done by this storm. Incoming steamers reported great quantities of wreckage along the transatlantic routes, and several vessels were added to the long list of derelicts on the high sea.

An inspection of the U. S. Hydrographic Office Pilot Chart for December, 1888, in the disturbed regions, will show the wrecks bearing dates coinciding with the passage of this great storm.

The gales experienced on the 7th about the 30th meridian must not be confounded with those from the above storm.

The following reports are selected from a great many, as showing the characteristics of the storm in its successive stages. All barometer readings have been corrected and reduced to sea-level and 32° F.:

The British steamship *Exeter City*, Captain Weiss, reported: November 8th gale set in from SW by S, at 7 A. M., in latitude 49° 15′ N, longitude 44° 03′ W, barometer 28.71. Hurricane for two hours, and violent hail squalls. A sea boarded us, smashed in the front of wheel-house and broke barometer. Gale moderated on the 10th.

The British steamship *Lake Superior*, Capt. William Stewart, reported: November 8th, 2 P. M., fresh gale from SSE; latitude 50° 41′ N, longitude 45° 43′ W, barometer 29.61. At 10 P. M., in latitude 50° 14′ N longitude 39° 20′ W, wind west, force 10, barometer 28.68, terrific hail squalls and sleet; high sea. Wind hauled to NW, and moderated on the 11th.

The British steamship *State of Pennsylvania*, Capt. A. J. A. Mann, reported: November 8th, 2 P. M., in latitude 50° N, longitude 38° 15′ W, barometer 28.53, very heavy gale from SE to WSW and NW, then backing more to the westward; squalls of hurricane force. Storm continued during 9th and 10th from NW; hail squalls. Composants on masts, yards, and rigging. Moderated on the 11th.

The Belgian steamship *Rhynland*, Capt. A. J. Griffin, reported: November 8th, wind SW by W; at noon, increasing to a moderate gale; sky overcast and threatening. Latitude 49° 56′ N, longitude 30° 37′ W. November 9, at about 3 A. M., wind veered to westward; barometer 28.90. Latitude 49° 14′ N, longitude 34° 03′ W. At 9 A. M., violent squalls. Afternoon gale moderating somewhat, but terrific squalls of rain and hail. Midnight, fine and clear between squalls. November 10, at 10 A. M., squalls blew with hurricane force. Hailstones as large as beans. Noticed St. Elmo's fire on all yard-arms, mast-heads, and fore-and-aft stays. November 11, gale moderated.

The German steamship *Slavonia*, Capt. A. Schmidt, reported: November 9th, gale set in from SE. At 6 P. M., in latitude 55° 25′ N, longitude 26° W, wind shifted to SW; barometer 28.57.

The British steamship *Tarifa*, Capt. W. S. Seccomb, reported: November 19th, strong gale from south; barometer 29.18; latitude 51° 36′ N, longitude 11° 40′ W. Wind shifted to SSE, west (through south), back to south, then veered to WSW and W by N. November 11th, wind backed to south again, thence to ESE, NE, and, at 9:30 P. M., to NW

force 11, with barometer 28.53, in latitude 51° 02′ N, longitude 22° 34′ W, then veered to NNE, and, on November 12, back again to NW, moderating.

The Belgian steamship *Nederland*, Capt. C. H. Grant, reported: November 11, blowing a strong gale from east; strong lightning and thunder, and wind steadily increasing. At 7:30 P. M., in latitude 50° 40′ N, longitude 20° W, barometer 28.50; terrific wind and rain squalls. On November 12, wind hauling from east to NE, north, and NW, and moderating.

Note.—Capt. Grant has also furnished a barogram, which has been invaluable in the investigation of the storm.

The British steamship *Buffalo*, Capt. J. H. Malet, reported: November 11, storm set in from south. November 12, at 3 A. M, in latitude 50° 29′ N, longitude 19° 10′ W, barometer 28.20. Ended same day. From 0:30 A. M. until 3 A. M., the disturbance was interrupted by light winds and calms, during which the wind shifted from SE to north and WNW.

The French steamship *La Bourgogne*, Capt. Frangeul, reported: November 10, wind SSE; blowing a gale throughout until 4 A. M. on the 12th, when, in latitude 50° 09′ N, longitude 14° 38′ W, the barometer fell to 28.40. At the same time the wind hauled to west, then to WNW, getting up a high sea, which embarrassed the vessel and retarded her considerably.

The British steamship *Etruria*, Capt. Cook, reported: November 11, gale set in from SE, then shifted to SSE, WNW, NNW, and NW. At 9 A.M., in latitude 51° 29′ N, longitude 16° 25′ W, barometer 28.89. From noon on the 12th, wind keeping between the points of WSW and NW. Strong breezes during the night and strong gales and squalls during the forenoon of the 13th.

NORFOLK STORM OF APRIL 6-10, 1889.

By A. H. Dutton.

This storm, the path of which is shown graphically on the accompanying chart, was one of the most severe that has visited the Atlantic seaboard of the United States since the disastrous hurricane of the latter part of November, 1888. Although its violence was remarkable, the erratic path it followed was even more so. Central on the great lakes on April 5th, the storm, instead of passing eastward over the usual route of depressions from that region, moved rapidly almost due south, and was central on the morning of the 6th, about 100 miles SW from Norfolk, Va. In that city, great damage was done by wind and wave, both on land and to the shipping in the harbor. About midday on the 6th

the storm recurved to the eastward, passing seaward about 9 P. M. As in the case of the great "March blizzard" of 1888, as the storm center approached the coast the influx of warm, moist air, from over the gulf stream caused a rapid increase of energy, and during the three succeeding days the storm raged with great fury.

Capt. O. W. Shailer, of the American schooner, *Frank O. Dame*, en-

countered it off the Virginia capes, and reported that he had "been going to sea for forty-three years, and never saw the equal of the hurricane of the 6th, 7th, and 8th of April." The violence of the storm is attested by a large number of reports from vessels encountering it at its height. The following brief abstracts are selected from many reports as showing

some interesting characteristics of this destructive storm at various stages:

U. S. Steamer *Constellation*, at Norfolk. During forenoon of Saturday the 6th, wind ESE. 5-8, squally, with rain, thunder, and lightning; barometer unsteady, between 29.73 and 29.84. During afternoon, wind moderating, force 3-8, varying in direction during lulls; barometer inclined to rise ; weather still ugly and threatening, with frequent lightning and thunder. At 1:35 A. M., on the 7th, barometer 29.84, a sudden squall from ENE, of hurricane force; occasional lulls, but squalls still violent. Wind continuing backing towards North until morning of the 7th, barometer at that time 29.97, and weather very threatening. From this hour until noon of April 8th, when the storm broke, the wind continued from N to N by E.

Captain Barber, British steamship *Tropic*, reports: Passed Cape Hatteras at 4 A. M. 6th, weather fine. At 7 A. M. (Greenwich noon), commenced to rain, wind SSE, fresh. 10 A. M., heavy rain and very loud peals of thunder, with lightning, which continued until 6 P. M.; wind then blowing hard from the NE by E, with high seas, increasing to a strong gale toward midnight. 5 A. M., wind blowing a hurricane with heavy seas and rain; what was apparently a ball of fire fell close to the ship, enveloping her with sparks; barometer vibrating a tenth of an inch. At 7 A. M. Sunday, when thick rain, engines broke down, ship heading to ESE, lying helpless in the trough of the sea until Wednesday, the 10th, when the weather moderated, and, the engines being again in working order, proceeded on voyage. Used oil with good effects.

Captain Wm. Petersen, American brig *Robert Howe*, furnishes a valuable report, the main points of which are as follows: April 5, 11:30 A. M., had a heavy squall from NW, with four heavy whirlwinds in a NW direction from ship. Position at time, latitude 31° 30′ N, longitude 71° 10′ W. April 6, moderate gale from ESE and cloudy, moderating during afternoon, wind veering to SE. Wind south at nightfall, and weather set in rainy, with thunder and sharp lightning. April 7, wind SW and squally; 5 P. M., saw a whirlwind traveling in an ESE direction, bearing SSW, distant two miles; position at time, latitude 34° 47′ N, longitude 72° 43′ W. At 9:30 P. M., moderated to a calm, leaving a high cross sea and strong tide-rips. At 1 A. M., 8th, wind came out suddenly from ENE in a heavy squall, and high sea from North. Storm continued with great force during 8th, moderating forenoon of 9th. Lowest barometer was 29.42, at 8 P. M., 7th.

Captain Shailer, American schooner *Frank O. Dame*, sends a very full and interesting report from which the following items are taken: He was compelled to heave-to at 7 A. M. Sunday the 7th, Fenwick's Island bearing about West, thirty miles; he remained hove-to until 7 A. M., Wednesday, when he found himself to be in latitude 35° 04′ N, longi-

tude 72° 15′ W. During the gale the wind backed from SE to NE, N, and NW. Just before heaving-to Sunday morning, he was standing to the southward, wind NE, when wind suddenly increased to hurricane force from same direction. Hail came with it, and it hailed hard for two hours, with such force that it was impossible to look to windward; could not see five hundred feet from the ship. After about two hours of hail, it began to snow, which continued about two hours, and then it rained in torrents for about five hours, the weather remaining very cold, but not freezing. The captain attributes the safety of his vessel to the use of oil.

Many other reports are at hand of the use of oil in this storm, all bearing testimony to the efficacy of this agent for lessening the dangerous effect of heavy seas.

After the 9th, the energy of the storm steadily decreased, but it retained its cyclonic nature for some time after. Its path after the 8th was about NE, until reaching the vicinity of Cape Race, on the evening of the 10th. From the 11th to 14th, inclusive, it lingered over Newfoundland and the Gulf of St. Lawrence, and resumed its eastward journey on the latter date. A report from Prince Edward's Island states that a severe snow-storm prevailed there on the 10th, but with comparatively mild temperature, the thermometer remaining above 38° F.

SPECTRE OF THE BROCKEN.

By Professor H. A. Hazen.

In the July Journal, at p. 128, is suggested an explanation of this phenomenon. This appearance seems to have attracted a great deal of attention, but unfortunately in most cases the explanation is given by some one who does not seem to have seen the apparition. One of the earliest notes is to be found in Rees's Cyclopædia (1810), as follows: "The effect of fog in apparently magnifying distant objects is notorious, it is an optical deception: the fog diminishes the brightness of objects, and consequently suggests a greater distance, but when the visual angle remains the same, the greater the distance the greater is the magnitude: hence objects at a moderate distance appear to be magnified." Johnson's Cyclopædia under "Brocken" gives: "The Spectre of the Brocken, seen here and elsewhere, is simply the reflection of the forms of men and other objects against the

sky, the *vapors of the atmosphere acting as a vast concave mirror;* (italics supplied), hence the objects reflected are seen greatly magnified." This same explanation (that it is a reflection) is given by Hartwig "Aerial World," p. 211. "There can be no doubt that the figure was a reflection of the lady from the thin mist rising from the damp ground. Sometimes the reflected image appears encircled with luminous rings, first described by the Spaniard, Ulloa, who relates that, as he stood at break of day with six companions on the summit of Pambamarca, in Peru, each of them, on looking towards the east,* saw his shadow in the centre of three rainbows, surrounded by a fourth circle of a single color."

In Warren's Physical Geography (1873), is the following: "Strange figures in the air are produced by natural objects, enlarged and distorted by peculiar reflection and are but varieties of the mirage." Alden's Cyclopædia (1888) gives: "The magnified shadow of men, houses, or other objects thrown upon the misty eastern horizon by the light of sunset."

Eclectic Physical Geography (1888) has: "The Spectre of the Brocken is a local name for a mirage." The July JOURNAL gives this explanation; the whole article should be read. "The enormous size of the shadows which figure in the descriptions are explained as the result of an error in the estimation of the distance. The observer thinks that the shadow is very large and very far away, whilst it is very near and of natural size."

The above is a summary of all the explanations found after a long search. The best illustration is in the French Edition of Mohn's Meteorology at page 438. A very good illustration of the Brocken Spectre on a cloud at a distance, with its surrounding anthelia and Ulloa circle, is to be found on page 132 of "The Atmosphere," by Flammarion. The artist is at fault in reversing the shadow, which seems to hold out its left arm while the object holds out his right.

Having recently spent several weeks on Mt. Washington, where this shadow is a very common occurrence, I desire to add the results of my observations. It seems to me that the

* This is evidently an error and should be *west*.

only views above of any importance are the first and last and yet even these seem entirely erroneous and advanced as possibly plausible. It is not at all probable that dimming a shadow would alter its apparent magnitude, and in the second instance the only way in which the size of the shadow could deceive the eye, because of an erroneous estimation of the distance, would be when it was a long distance off—the nearer the shadow the less likely that the eye would be deceived. There is danger of confounding two phenomena quite similar in their origin but entirely different in appearance. If the observer stands on an eminence very near sunrise or sunset, and when the sun is clear, he will see upon a cloud, if there be one on the opposite side of the sun at distances of 100 to 500 feet, a slightly diminished shadow of himself. This is the appearance seen by Prof. Langley on Pike's Peak, as described on page 130 of the July JOURNAL, and it is entirely different from the "Brocken Spectre" proper. Under favorable conditions this shadow will have beautiful circular mist-bows (anthelia) surrounding it. I have counted four of these mist-bows, with the prismatic colors nearly perfect in the three inner. Some observers have noted a whitish circle (Ulloa) outside of the anthelia, but this was not noted on Mt. Washington.

If the cloud or fog completely envelops the observer, or approaches very near him on the side opposite the sun, there appears an enlargement of the shadow which seems to emanate directly from the body. The following explanation is advanced: At sunset or sunrise, on a level plain, the shadow of a person is greatly elongated. It starts at the feet and disappears in the distance. When the fog is completely around one it forms what may be called the "ground" in the above illustration, but this is all about and not merely below, in consequence the arms and legs of the shadow are elongated and appear to start from the observer to disappear in the distance. It is not difficult to see that to the eyes of one unused to such phenomena the appearance would be deceptive if not terrifying. Owing to an almost perpetual gale on Mt. Washington which blows away the fog masses and also to the fact that fogs are usually too dense to

display the phenomenon at its best, it was by no means an easy matter to make a thorough investigation. It was found practicable, however, to study the shadows very carefully at night by using a lantern having a reflector which threw a sharp beam of light upon the observer. This phenomenon was witnessed by hundreds during dense fogs when nothing else could be seen on the summit, and always elicited expressions of admiration.

It seems to me this whole matter shows very clearly the great danger of attempting to theorize upon any subject in meteorology in regard to which we have not sufficient observational data.

September 19, 1889.

Note added November 1.—At Prof. Harrington's suggestion I add the following description of the phenomenon: A dense fog prevailed for more than half the time at night on Mt. Washington. In making the experiments the lantern was placed at a distance of about eight feet from the observer and the latter usually stood in a doorway with the light in the room behind. This arrangement cut off all side light and gave a pyramidal beam of light of great dimensions extending out in the fog till lost to view from dimness. The shadow began at the person of the observer, which could very easily be told by looking at the arms or legs, and extended out in the fog. The manifestation was rendered much more vivid by violently moving the limbs or body. Each part of the body cast the *shell* of a shadow, if such an expression can be allowed, that is, the light was cut off from the fog and, in consequence, there appeared to be a broad shadow, clear out as far as the light shone, exactly defining the arm or leg. The observer looked, as it were, directly *into* the shadow. It is a little difficult to give an exact description but we may be helped to understand the matter by considering the phenomenon called sun "drawing water." In this case the object casting the shadow on the haze or fog may be a very small cloud, but the length of the shadow itself is all out of proportion to that of the cloud.

It might be thought at first sight that the nearness of the light to the observer caused the enlargement, but this could have

been the case only if the shadow had been cast upon a distant wall or cloud with no intervening fog particles. Here, however, the fog particles enveloped the observer and there was no difficulty in seeing that the shadow began exactly at his body where there could have been no enlargement. This same appearance may be observed by any one when a fog occurs. Let the person stand in the fog with his back to the light and he will at once see his shadow apparently greatly enlarged disappearing in the fog.

Since writing the article I have come across quite a full description of this appearance and citation of authorities by Mr. Sharpe, in the *Quarterly Journal*, Royal Meteorological Society, 1887, pp. 245-272, and all who are interested will find the article very exhaustive and valuable. Prof. Harrington has also referred me to a full description and attempted explanation in Müller's "Kosmische Physik," pp. 430-438. There is a seeming contradiction in Figures 263 and 264, owing to a confusion in two phenomena which are entirely distinct. Both of these were seen on Mt. Washington and they will shortly be described.

November 2, 1889.

RAINFALL IN MICHIGAN—MARCH.

By N. B. Conger.
Director State Weather Service.

The distribution of rainfall for this month is quite even, and the average for the State is 2.50 inches, which is nearly the average amount for each section in the Lower Peninsula, while the amount in the Upper Peninsula is but 1.65 inches. The light rainfall in this section still continues below two inches.

The precipitation for this month is not subject to great changes, and of the records of twenty-four stations whose records extend back in some cases to 1871 and all to 1876, there is recorded but two years in which the precipitation exceeded four inches, and two years when it was less than one inch. In the southern section in 1877 the amount was 4.47 inches, while 5.50 inches was recorded at Detroit, in 1876, while the remain-

Michigan Weather Service
in co-operation with the
U.S. Signal Service,
Precipitation Chart.
March Normal
13 Years Observations
Lake Superior
Luce
Alger
Schoolcraft
Mackinac
Chippewa
Delta
1.83
Isle Royal
Keweenaw
Houghton
Ontonagon
Baraga
1.46
Gogebic
Marquette
Iron
Wisconsin
Menominee
1.83
Emmet
Cheboygan
Presque Isle
Charlevoix
Antrim
Otsego
Montmorency
Alpena
2.23
Scale of Shades.
0 & 2 Inches
2 & 3 "
3 & 4 "
4 & 5 "
Over 5 "
Lake Huron
Kalkaska
Crawford
Oscoda
Alcona
2.07
Benzie
Gr. Traverse
2.28
2.40
Manistee
Wexford
Missaukee
Roscommon
Ogemaw
Iosco
2.19
Lake Michigan
Mason
Lake
Osceola
2.12
Clare
Gladwin
Arenac
Saginaw Bay
Huron
Bay
Oceana
Newaygo
Mecosta
Isabella
Midland
2.42
Tuscola
Sanilac
Muskegon
Montcalm
Gratiot
Saginaw
Kent
Genesee
Lapeer
Ottawa
2.40
Ionia
2.49
Clinton
Shiawassee
2.30
2.54
St. Clair
Allegan
Barry
2.60
Eaton
Ingham
2.12
Livingston
Oakland
2.42
Macomb
2.44
Van Buren
Kalamazoo
2.72
Calhoun
2.25
Jackson
Washtenaw
2.14
Wayne
2.60
Berrien
Cass
St Joseph
2.58
Branch
2.47
Hillsdale
2.95
Lenawee
Monroe
Indiana
Ohio
Lake Erie

der of the south half of the State received an average of 3.25 inches. At Alpena amounts exceeding four inches have occurred only in 1882, 4.62 inches, and 1886, 5.56 inches, the records beginning in 1873. At Marquette rainfalls of less than one inch occurred in 1872-3-4-7, and 1883-4, while the maximum amount recorded at this station was 3.84 inches in 1881. On the west half of the State, at Grand Haven, rainfalls of four inches or more occurred in 1878, 4.51 inches, and 1882, 5.85 inches, while further south in Berrien county, an amount of over four inches has occurred but once, in 1877, 4.47 inches.

In St. Joseph county in 1877 an amount of 7.02 was recorded, and 7.33 inches at Kalamazoo in the same year. This latter amount is the maximum that is recorded on the files of this office. These are the most marked peculiarities of the extremes of the rainfall in this State, and a study of the accompanying chart shows that there are no marked changes in the averages for the different sections, and that the same average amount may be naturally expected each year, from the history of the past. In the Southern Peninsula there have been no continued drouths in this month, and the years in which light rainfall has occurred do not follow each other, but an average amount of rainfall will generally intervene. In following this matter up it is unfortunate that there has not been kept in the past years the average amonnt of snowfall that has fallen during the month, and the amount on the ground at the close of the month, as is now the case. This datum would be of great value at this time in comparing the results now obtained with the results of former years relative to the average fall of snow for the winter months.

ROYAL METEOROLOGICAL SOCIETY.

The usual monthly meeting of this Society was held on Wednesday evening, December 18th, at the Institution of Civil Engineers, Dr. W. Marcet, F. R. S., President, in the chair.

Thirty-nine new fellows were elected.

The following papers were read:

(1) "Report of the Wind Force Committee on the Factor of the New Pattern Robinson Anemometer." This has been drawn up by Mr. W. H. Dines, who has made a large number

of experiments with various anemometers on the whirling machine at Hersham. Twelve of these were made with the friction of the new anemometer artificially increased, seven with a variable velocity, and fourteen with the plane of the cups inclined at an angle to the direction of motion. In discussing the results the following points are taken into consideration, viz., the possibility of the existence of induced eddies, the effect of the increased friction due to the centrifugal force and gyroscopic action, and the action of the natural wind. The conclusion that the instrument is greatly affected by the variability of the wind to which it is exposed, seems to be irresistible, and if so, the exact value of the factor must depend upon the nature of the wind as well as upon the mean velocity. There is evidence to show that during a gale the variations of velocity are sometimes of great extent and frequency, and there can be but little doubt that in such a case the factor is less than 215. The one point which does seem clear is that for anemometers of the new pattern the value three is far too high, and consequently that the registered wind velocities are considerably in excess of the true amount.

(2) "On Testing Anemometers," by Mr. W. H. Dines, B. A. The author describes the various methods employed in the testing of anemometers, points out the difficulties that have to be encountered, and explains how they can be overcome.

(3) "On the Rainfall of the Riviera," by Mr. G. J. Symons, F. R. S. The author has collected all the available information respecting rainfall in this district, which is very scanty. He believes that the total annual fall along the Riviera from Cannes to San Remo is about 31 inches, and that any difference between the several towns has yet to be proved.

(4) "Report on the Phenological Observations for 1889"; by Mr. E. Mawley. This is a discussion of observations on the flowering of plants, the appearance of insects, the song and nesting of birds, etc. Taken as a whole, 1889 was an unusually gay and bountiful year.

The Society has its eleventh annual exhibition of meteorological instruments on March 18th to 21st, in its rooms in London.

CLIMATIC TREATMENT OF PHTHISIS PULMONALIS.

[The following extract from a paper read before the American Medical Association at its last meeting, by W. L. Schenck, M. D., of Osage City, Kansas, is a fair sample of the views at present held by the thoughtful general practitioners in this country as to the therapeutic influences of the various elements of climate in the cure of pulmonary consumption.

The value of each factor as pure and dry air, equable and moderate temperature, abundant sunshine, moderate elevation, are getting to be very generally conceded.

The chief want now felt by the medical profession is a complete and unbiased record of these climatic conditions in localities that are not so remote from populous regions, but that patients in the early stages of the disease may reap their benefits without the necessity of abandoning all occupation with no opportunity to moderate the expense, otherwise but a very limited proportion of those affected with this ever prevalent disease will be able to avail themselves of the advantage that a change of climate might afford.—Ed.]

Prof. Jaccoud, than whom we have no better authority, in his work on "The Curability and Therapeutics of Phthisis," considers the disease curable in all its stages—not all cases, but curable as are other diseases. In all treatment he relies largely upon the influence of climate, adapting its conditions to the individual case. Notwithstanding Jaccoud's dictum, there are widely differing opinions as to which is the best climate; thus, we find the balmy air of sea-surrounded Orotava praised, the soft warm breezes of St. Augustine, Fla., the fragrant odors and almost tropical warmth of the Louisiana pine-belt, the high cold climate of Colorado, and the damp and chilly atmosphere of lake-girt Michigan.* As these widely differing opinions seem but the varied notes of "Home, Sweet Home," we must consider principles and statistics.

Before we can give intelligent advice to invalids we must understand the various elements entering into and producing

* Transactions International Medical Congress, Vol. V.

what we call climate, and their impress upon life, as thoroughly as the etiology and pathology of disease. Webster defines climate as "the condition of a place in relation to the various meteorological conditions, as temperature, moisture, etc."

Climates are mainly created and influenced by latitude, topography, superficial strata and the presence or absence of large bodies of water, and are the aggregate of atmospheric conditions of particular localities at specified seasons. The chief elements to be considered in climatic treatment are: 1, purity; 2, rarefaction, as produced by altitude; 3, dryness; 4, temperature; 5, variability; 6, sunlight; 7, electricity; 8, atmospheric motion. The first and second elements are chiefly influenced by altitude, the others by latitude, configuration, and porosity of the surface and relation to bodies of water.

Dr. Dennison advocates the "dry, cool, rarefied, stimulating and sunny atmosphere of Colorado," because, among other reasons, "cold stimulates and heat depresses." Is not this as fallacious as the Thompsonian dogma, "heat is life, and cold is death?" A limb mutilated beyond hope of recovery is restored through the stimulus of hot water dressings, and a frightful post-partum hæmorrhage is arrested by the stimulus of hot intra-uterine injections. "*In media tutissimus ibis*" must be one rule in selecting temperature for the consumptive. An atmosphere that stimulates through altitude, and yet wooes to out-door life, is most favorable for the prevention and cure of phthisis. It is not the heat or the cold that tends to cure in phthisis. Robust health may endure an inhospitable climate, but such a climate does not produce robust health in those of marked tuberculous heredity; while in damp air, cold or warm, containing less oxygen than dry air, which is absorbed less readily from the moist membrane, there is diminished oxidation of the blood engorgement of central organs. Dr. Dennison thinks nightly chilling and sometimes freezing renders the atmosphere "inimical to germ life." We don't know so much about the health of the germ, but we know such conditions are inimical to human health.

Whether from the direct effect of abstraction of moisture

from the pulmonary tissue, or the consequent control of pulmonary temperature, or other cause, a dry atmosphere is essential to climatic treatment. Change in temperature, when the range is not too wide, may not injure vigorous life; but the alternations of temperature, the hot days and cold nights, so common in all damp climates, leads to engorgement of central organs--spleen ,liver, kidneys, lungs,--to periodic and congestive fevers, to lowered vitality and to consumption, wherever the predisposition exists. Damp, hot days and damp, cold nights produce directly opposite results to dry, high altitudes, where external tissues are hyperæmic and internal organs anæmic. Cold condenses the atmosphere. In cold weather, at low altitudes, the full use of the pulmonary tissue and circulation is not required, and there is tendency to atony and the tubercle cell. In simply cold climates, of whatever altitude, sudden and extreme changes fall heavily upon the exposed lungs, and such changes cannot be avoided. Much of the time must necessarily be spent in artificially heated rooms, too often illy ventilated, between which and the out-door air there is a difference of many degrees. It goes for the saying that the advantage of climate is the climate and not the heated air of the living room. A climate that permits and invites out-door life is a necessity to satisfactory climatic treatment. Cold and rain confine the patient in-doors; a warm, moist air tempts to indolence, and a hot, dry air leads to idleness and the shade, while a high, dry air of vernal temperature stimulates to out-door life and exercise, and so fills all the conditions of climatic treatment.

Climatic treatment is based upon more rational grounds than the destruction of germs. In an atmosphere rarefied by altitude the pressure upon the surface of the body is diminished and the vessels of the periphery are turgescent, while the viscera are comparatively anæmic. The pulmonary circulation freed from hyperæmia, congestion and obstruction, tendency to hæmorrhage is prevented or relieved, respiration is full and free, the cerebro-spinal functions are more active, the great central glands relieved of remora and congestion, effete matter is more

thoroughly removed, the appetite, digestion and nutrition are improved, the desire and capacity for exercise increased, and we begin to feel

> "The wheels are just as strong as the thills,
> And the floor just as strong as the sills,
> And the panels just as strong as the floor,
> And the whippletree neither less nor more,
> And the back crossbar as strong as the fore,
> And the spring and axle and hub encore."

The "hardy mountaineer," with his physical and mental activity, does not owe all his growth to mountain scenery, but illustrates the beneficial effects of altitude. The rarefied atmosphere and the relative anæmia of the lungs, other things being equal, demands and permits full drafts of air, while the brain and all the great vital organs, permitting an unobstructed circulation of the vital current, tissue degradation and deterioration are prevented or relieved.

Prof. Jaccoud says: "Mountainous climates at the height of from 4,900 to 6,200 feet have in reality a double effect: Firstly, a general one, by which the constitution is restored to a healthy condition; secondly, a local one, by which the activity of respiration is increased to a maximum, while the lung is protected from the effect of congestion and hyperæmia. Climates which, on account of their more northern latitude, present analogous conditions of temperature at a lower altitude, produce the same tonic effect. They have not, however, the same mechanical influence upon the lungs, this being entirely due to barometric pressure. Climates with moderate pressure are wanting in the mechanical action of rarified atmosphere, and there is insufficient tonic and fortifying effect; nor do they possess that special purifying effect peculiar to high latitudes; they therefore fulfill only secondary indications—secondary in themselves, or at the time when they occur. While such climates have no curative effects on the disease and are not preventive of fresh tubercle, they may, on account of having a temperate, or warm, fresh temperature in winter, act favorably upon any preëxisting bronchitis or pulmonary catarrh. Confinement within doors is unnecessary, and much of the time may be spent in the open

air without danger of provoking bronchitis or pneumonia, which would not be the case in a more rigorous climate, or one having greater variability of temperature. It is thus seen that climates of the second class, while of an undoubted value in the treaument of phthisis, are only of secondary importance."

Altitude in any latitude that does not permit to the consumptive out-door life loses much of its advantage. If we can find a locality with a comparatively dry atmosphere which at 4,000, 6,000, 8,000 or 10,000 feet will permit patients to live largely out-of-doors, they will at the same time get the benefit of barometric pressure, climate and healthful exercise. Though not a resident of New Mexico, its barometric pressure will range from 4,000 to 10,000 feet, with a climate that will permit and stimulate out-door exercise, with which its hygrometric conditions will rarely interfere.

The damp, cold climate of lake-encircled Michigan is excellent for consumption, but bad for the consumptive, and its statistics prove what science teaches. According to the census reports of 1870 and 1880, it has a higher death-rate from phthisis than any other inland State in the Union. Of its deaths in 1870, 16.4 were from phthisis, and in 1880, 13.2.

In the States lying upon and near either ocean in the northern portion of the United States, notwithstanding their altitude we have the highest death-rate from phthisis, the acme being reached in Maine, where, in 1870, 25.6 of the deaths were from consumption, and in 1880, 19.2; in New Hampshire they were 22.2 in 1870, and 15.7 in 1880; in Massachusetts, 19.9 and 15.7; in Connecticut, 17.9 and 19.2; in Rhode Island, 20.1 and 14.7; in California, 13.8 and 15.6; in Oregon, 18.2 and 12.1.

The warm, damp air of the Gulf States, with their lower altitude and higher temperature, give much more favorable statistics than those somewhat similarly situated as to moisture, but with more rigorous climates. Thus, the percentage of deaths from phthisis, as shown by the census of 1870 and 1880, were 5.7 and 8.0 in Georgia; 6.4 and 8.0 in Alabama; 7.0 and 9.0 in Mississippi; 7.0 and 8.2 in Florida, and 7.7 and 8.2 in Louisiana.

Colorado and Nebraska, so highly lauded for the influence of their climate on the consumptive, show by the same census a slightly larger proportion of deaths from phthisis than the low-lying but warm States on the Gulf of Mexico. Thus, in Colorado 8.5 and 8.2 were from phthisis, and in Nebraska, 8.7 and 7.0. In New Mexico the deaths from phthisis are given in 1870 as 3.8, and in 1880, 2.5, and in Arizona, 4.0 and 6.9, and this where the native population suffer largely from a specific disease that tends to a type of phthisis.

From the view we have taken of the etiology and pathology of phthisis, as well as from statistics, we conclude that a sanitarium for consumptives in New Mexico, away from the hot springs, with their excess of moisture, upon an arroyo of 4,000 or 5,000 feet above the sea, with cottages extending up the mesa to 10,000 feet, permitting patients to be moved up or down, as their condition permits or requires, will secure to the consumptive all possible climatic advantages and make for them the most perfect retreat known to any country or clime.

Yet we must remember that in all climatic treatment we must "temper the wind to the shorn lamb." In the flat and narrow chest, in tuberculous deposit confined to the apex, or yet more extensive if the purulent stage has not been reached, altitude, high, dry and equable, with a climate that encourages out-door life, is positively preventive and curative, not in a day or a year, but continued until the cure is complete. When caseation and softening are more extended, a mild, dry and pure atmosphere is required, such as may be found in the lower altitudes of New Mexico and in the Carolinas, Tennessee and Georgia. When the tuberculous deposit is extensive, expectoration copious, hectic marked and emaciation extreme, the probabilities of cure are so small that the pleasures of home, where love may make the dying bed "soft as downy pillows are" should not be exchanged for an arduous journey to end in a final struggle away from the comforts and consolations of home and friends.

IS THE PREVAILING INFLUENZA CONTAGIOUS?

The following communication to *Science*, February 7th, by M. C. Collins will be of interest in view of the uncertainty which still exists as to the manner in which the exciting cause of *la Grippe* is conveyed from place to place. It is quite probable that both air currents and the inter-communication of mankind may be channels for the propagation of the etiological factor of the disease. He says:

I live on the Sioux Reservation, thirty-two miles from Fort Yates, the nearest white settlement. We have had a clear cold winter, west winds prevailing, few colds, and but little sickness except whooping-cough among children.

Over on the other side of the river, north of this about thirty or forty miles, is a Russian settlement. I have heard continually of late of their having influenza over there. I had no faith in the disease being epidemic or contagious. A short time ago a few of our Indians went over there trading. We had no signs of the disease here. They returned, and in less than a week one of the families who went were all down with what I thought hard colds. I was called in to treat the cases. In three days, three more strong men were down; and now the whole Indian village is suffering with it, and I am just coming down with it myself. The patients have aching heads, and pain in the side and lungs, the whole body aching as if with ague. They are feverish, troubled with coughing and hoarseness, are restless, and have no appetites, but great thirst. Is it influenza? If so, influenza must be contagious. We have such cold weather, surely disease-germs would not survive; and our winds, being mostly west winds, could not bring disease-germs from the east. This may be of no use to science; but I am so isolated here,—being a missionary among the Indians, and the only white person here,—I thought it might have weight in some direction.

FORT YATES, N. DAKOTA, January 24.

CORRESPONDENCE.

INDIAN SUMMER.

To the Editors: — If the Indian summer spoken of by Prof. Richard Owen in the Journal for January, as occurring in the Valley of the Mississippi be the same meteorological phenomenon as that long known in southeastern Pennsylvania by the same name, it would seem to me that he has gone very far around "Robin Hood's barn" and to considerable unnecessary scientific research to account for a simple phenomenon, and one that can be easily explained.

About sixty years ago, one fall, when but a lad, I heard some one ask my father how he accounted for the Indian summer then prevailing, and for its regular annual recurrence at about the same time. He kept a diary, and was an authority upon many matters with his neighbors. I noted his reply, which was that the winds at this season of the year were generally from the west and northwest, and that the smoky atmosphere here was caused by the burning of old prairie grasses in Ohio, Indiana and Illinois by the Indians then still holding the principal parts of those states. The object was to destroy the dead grasses, so that they would not interfere with the luxuriant growth of the new crops next spring, and then it would furnish more abundant pasturage for game. In later years, by close observation, I was fully confirmed in the correctness of my father's judgment. In the first place, from fifty to sixty years ago, we looked for Indian summer late in every fall with much confidence, and it seldom failed to come on time. The atmosphere was not just what might be called hazy or foggy as Prof. R. Owen suggests, but distinctly smoky with a strong odor of burning vegetation. Gradually for a few years these Indian Summers became less and less distinctively smoky, until the white man came in full possession of the states named, since when the smoky appearance of our Indian summers has almost entirely disappeared. We still have those few clear mellow days in the autumn, which may or may not be slightly hazy,

but the smell of burning grasses, so very noticeable in my youth, is no longer to be perceived by ordinary nostrils.

As a further confirmation in these views, I would state that about two days after the great Chicago fire which occurred some twelve or fifteen years ago, (I have not the exact date now at hand), whilst out in the fields on my farm in Chester county, Penn., I noticed that a very smoky atmosphere prevailed around, very similar to that in our old Indian summer; in looking for a cause, I noticed that it had a strong, distinct smell peculiar to the burning of groceries, with which I had long been familiar as an old city fireman. There had been no important fires reported in any direction for some time other than that in Chicago, and none of any kind within one hundred miles of my place. I could therefore only trace it to the one source, the Chicago fire. The wind had been steadily from the northwest and quite dry from the time of the breaking out of the fire until noticed by me. How long this state of the atmosphere continued I am not now certain, but I think for three or four days, or until a rain. I satisfied myself that there could be no mistake as to where that smoke came from, nor in the character of a portion of the material whence it came. I see no reason why the old Indian summers should not have occurred in the New England states as well as here, if the winds remained steadily from the burning prairies in that direction say for three days.

JOHN PLOWSHARE.

West Chester, Pennsylvania.

CURRENT NOTES.

BLUE HILL METEOROLOGICAL OBSERVATORY.—The publication of the observations for 1888 follows rapidly on that for 1887 which was noticed on p. 40 of this volume of the JOURNAL. This one is in the same form, and published under the same auspices as the preceding, but lacks the two or three special studies which were printed in the volume for 1887. This observatory is generally recognized as the best equipped in the United States, and as one conducted in the true scientific spirit.

It would make the tables, more convenient for use if the data for the international hours were repeated in separate tables, for ease of comparison, map-making, and similar studies.

MISSOURI RAINFALL.—Professor Nipher has reported to the St. Louis Academy of Science (Trans. V, No. 3) on the Missouri rainfall, collecting all observations at hand and giving averages for ten years, ending December, 1887. The report is accompanied by maps of monthly, seasonal and annual rainfall. The mean annual rainfall varies from 44 inches on the Southern to 32 inches on the Northern border. The mean for the entire state is 38.28 inches. He finds also that the average amount of rainfall per second is 195,800 cubic feet, while the average discharge of the Mississippi river opposite St. Louis is 190,800 cubic feet so that it appears that if all the rainfall of Missouri reached the rivers it would cause a larger outflow than is actually afforded by the entire drainage basin of the Mississippi river above St. Louis, and this includes the entire basin of the Missouri river. This drainage area contains, as Professor Nipher found, in this as in other cases by the planimeter, 733,120 square miles. Missouri contains 69,415 square miles, or less than a tenth as much.

THE NEW ENGLAND METEOROLOGICAL SOCIETY now publishes its reports in co-operation with the Astronomical Observatory of Harvard College. The latest monthly bulletin at the date of writing is that for August, 1889, and this is number 58 of the series. In this month reports were received from 156 observers. Of these one was at St. Johns, N. B., and five in New York. With this number we received also the appendix for the year 1888, containing a summary of the observations for this year. The number of stations which had reported during the year was 172; the number of reports received each month ranged from 132 to 151. The appendix gives the tables of means of observations for the year and also discusses the characteristics of the weather in this time. It may interest our readers to know that 88 cyclones affected the weather of New

England during the year, of which 31 only passed over it, 34 passed to the north, eight to the east, and four to the south. Six originated over New England, and five were dissolved before reaching it but near by. The distribution of the 88 through the months is quite uniform, but those which passed to the south, or originated in it, or died out near by, were all of the warmer season.

DR. GORE'S BIBLIOGRAPHY OF GEODESY*. To many of our readers this bibliography will be of great importance, and to all meteorologists it is of interest. It includes about 6000 titles relating to the figure of the earth and the operations for finding it, including the theoretical as well as the practical side of the use of the pendulum. In making the list Dr. Gore has visited all the principal libraries at home and abroad, and he was aided by librarians and bibliographers until he considers it fairly complete. The relation between Geodesy and kindred sciences are very close and it is doubtful in many cases where to draw the line. We note that Dr. Gore has, in Practical Astronomy for instance, referred to Doolittle's Practical Astronomy, but has referred only to the appendix on least squares in Chauvenet's Astronomy, while he fails to refer to Brünnow, or Loomis. Again, while there is a long list of references on "Standards of Length," there seem to be no star-list in the entire bibliography; such standard lists as the B. A. C., Yarnall's, Heis's, Newcomb's, and even Boss's Latitude Stars, are omitted. We do not call attention to these in a spirit of criticism, but rather to indicate to our readers what are the limitations adopted by Dr. Gore. All references to tides seem to be omitted and under geographic position are given only references of a general character, while such subjects as probable error, gravity, signals, etc., have full references.

It is a source of congratulation that this valuable list is published by our Coast Survey. This list and those on temperature

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* U. S. Coast and Geodetic Survey, F. M. Thorn, Superintendent, *A Bibliography of Geodesy*, by J. Howard Gore, B. S., Ph. D., Professor of Mathematics, Columbian University, etc. Appendix No. 16. Report for 1887, Washington, Gov. Printing Office. 1889. Quarto, pp. 313-512.

and moisture, published by the Signal Service, show that American science and American libraries have reached a stage where we can do creditable bibliographical work.

SPECIAL RAINFALL PUBLICATIONS OF THE SIGNAL SERVICE.*— The three publications, the full titles of which are given below, place a great deal of valuable information at the disposition of meteorologists generally. The first contains the monthly rain-charts for the four years 1870-1873. They are of the size and form of those now published in the *Monthly Weather Review* and are intended to complete the series of the latter. They were made from data not previously utilized and were principally for the use of the Signal Offices, but enough copies were printed for distribution to voluntary observers.

The second is a report called for by the Senate and was made about the middle of February, 1888. It contains the rainfall charts for each month and for the year for the states and territories named in the title, and the tables from which these were made are given in the text. The series of charts is completed by one of the least known yearly rainfall and one of the greatest known. Every source was exhausted in the preparation of the data and they were brought down to the end of 1887. In the text, General Greely discusses the general features of the problems of rainfall and irrigation, and Lieut. Glassford discusses briefly the causes of wet and dry seasons on the Pacific slope, and the summer rains of Arizona.

The value of these maps and tables can hardly be questioned. Six hundred and sixty-one stations were utilized in their construction and the average duration of observations was over seven years. Among many interesting features brought out we may mention that the area of the region over which ten inches

* Charts showing the Rainfall in the United States for each month from January, 1870, to December, 1873. Based largely on reports from Voluntary Observers. Washington, Signal Service Office, 1888. Quarto, 48 charts.

Report of Rainfall in Washington Territory, Oregon, California, Idaho, Nevada, Utah, Arizona, Colorado, Wyoming, New Mexico, Indian Territory and Texas, for from two to forty years Washington, Gov. Printing Office, 1889. Quarto, 100 pp., 15 Maps.

Letter from the Secretary of War, Transmitting Letter of the Chief Signal Officer on the Climate of Oregon and Washington Territory. Washington, Gov. Printing Office, 1889. Quarto, 37 pp., 7 Charts.

or less of rain falls annually has been reduced from the 241,000 square miles of the tenth census to 126,000 square miles. And the area over which less than fifteen inches falls,—what may be properly called the "arid region"—is reduced from 626,000 square miles to 385,000. In other words the arid region is reduced, in the light of better and more recent knowledge, by nearly a quarter of a million square miles.

The charts of the third publication are the mean annual precipitation, that for the wet season (October to April), that for the dry (May to September), average number of rainy days, and the mean temperatures for the year, and for the winter. The tables are given in the text. The date of the report is October, 1888.

JANUARY STORMS.—This month was remarkable for the tempestuous weather that prevailed almost uninterruptedly over the transatlantic steamship routes. Storms succeeded each other in rapid succession, the majority of them having developed inland and moved ENE, on very similar paths, from Nova Scotia and across southern Newfoundland. The most notable storm of the month was probably the one that developed in the St. Lawrence valley, and moved out to sea across the straits of Belle Isle early on the 3d, when it was central about latitude 52° N, longitude 48° W. It then moved nearly due east, rapidly increasing in intensity, until reaching the 20th meridian, when it curved to the NE'd and was central on the 5th about latitude 55° N, longitude 17° W, and disappeared north of Scotland. The barometric pressure in this storm was remarkably low, the lowest corrected reading reported being 27.93, at 4 P. M., January 4, about latitude 53° N, longitude 23° W. This was reported by Captain Johnson, of the British steamship *Connemara,* who further states that the storm was accompanied by winds of hurricane force, with terrific squalls, occasional hail, and mountainous seas. The following reports have been selected as typical of the many that have been received from vessels that encountered this storm and others that succeeded it:

Second Officer Henry Stubbs, of the British steamship *Ceph-*

alonia, which sailed from Liverpool January 2, for Boston, furnishes the following admirable report: January 3, wind moderate from NW, and varying between this point and WNW, with long NW'ly swell. Appearance of weather was fine, but the barometer was falling very rapidly. During the first watch, observed faint streamers of the aurora borealis; toward midnight wind backed into SW and S. January 4, at 7 A. M., wind increased to gale and toward noon was blowing a storm from SSE, with wild, broken sea. At 1 P. M., wind hauled SSW, and very gusty. Was struck by a very heavy squall, with thunder and lightning, and blinding rain and hail. The peals of thunder broke over the ship like a volley of artillery. Barometer pumping and falling until 7 P. M., in latitude 51° 19′ N, longitude 16° 01′ W, when it reached 28.38 and remained stationary for about two hours, the wind and the squalls blowing with hurricane force; after rising .3, the barometer steadied, the wind hauling from SW by W to W by N, with frequent violent squalls, accompanied by sharp rain and hail. January 5, 7:12 A. M., barometer 28.93, in latitude 51° 40′ N, longitude 17° 38′ W; wind abated a little, but continual strong fresh gales, with high broken sea. Estimated the height of the seas to be from 40 to 45 feet. January 6, at noon, wind backed again into the SE, gale freshening, with fierce squalls from S and SW, accompanied by hail, then lulling and veering between SSE and W. Lowest barometer 28.96, at 3:48 P. M., in latitude 50° 51′ N, longitude 24° 47′ W. (The *Cephalonia* was now encountering the second storm). Squalls blew with hurricane force and would last 15 or 20 minutes. This continued for about two hours and a half, when the weather moderated to moderate gale, with confused sea. The barometer since noon had fallen 0.23, when it began to rise. At 11 P. M. the gale abated, wind hauling to WNW. January 7, moderate NW winds, backing to S'd, and freshening, with confused swells. At 9 P. M., wind increasing to strong gales from SE and hauling to SW, with rough broken sea (another storm was now being encountered), heavy sprays sweeping the ship fore and aft. Barometer falling until midnight, then began to rise. January 8, at 2:10 A. M., latitude 39°

31′ N, longitude 34° 11′ W, barometer 29.12; strong gale, with high breaking sea; wind hauling to westward, with sharp showers, accompanied by hail. January 9, at 4 A. M., weather moderating; wind fell light, and toward noon backed around to SE, hauling to WSW, then backing to SW by S; sky very clear and horizon hazy. Toward midnight gale increased to storm, sky clouding up from the W'd. January 10, 2:59 A. M., latitude 47° 05′ N, longitude 44° 04′ W, barometer 28.69. At 7 A. M. fierce storm, with blizzard and very high breaking sea, causing the vessel to labor and to ship large quantities of water fore and aft. (This was the storm central at noon on the 10th in about latitude 50° N, longitude 45° W). Continual squalls to the W'd, with blizzard, blowing with hurricane force, and covering the ship with blinding spray. At 4 P. M. thermometer registered 8°; sea running very high. January 11, 2 A. M, weather moderating; occasional passing squalls, with light snow; wind WSW; thermometer 12°. During the forenoon, set in with snow, weather at times very thick. Toward noon cleared. Afternoon cloudy, with fresh wind from WNW; thick snow at times.

Mr. T. A. Whistler, of the British steamship *Germanic*, reports that on January 4 a gale set in from SW, but wind very unsteady from SW by S to NW from 12 hours before to 12 hours after the gale. Lowest barometer at 2:40 P. M., when it read 27.99, in latitude 51° 10′ N, longitude 25° 28′ W. Hard gale, with fierce snow and hail-squalls.—*Pilot Chart for February.*

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DR. MARCET ON TERRESTRIAL RADIATION.—The following passage occurs in an address by Dr. W. Marcet, F. R. S., on "The Sun, its Heat and Light," delivered before the Royal Meteorological Society, March 20, 1889 :

"After sunset, the earth acquiring no further heat to make up for that it gives out, undergoes rapid cooling, and the temperature of the air in contact with it is also reduced. But you will ask, what becomes of the heat the earth is thus giving out after sunset and at night? This heat rises through the air until it

comes into contact with moisture, and there it is first of all arrested, and next converted into the motion required to expand the moisture and increase its vapor tension. Hence it is that at sunset and for some time later the air is found to be warmer at a certain height above the ground than it is on the earth's surface. . . . . The radiation of terrestrial heat into space after dark is clearly concerned in the fact that nights are, as a rule, so much finer than days. The clearer nights are due to a combination of circumstances, the principle of these being, first, the increased temperature at night in the higher atmosphere; and secondly, the diminished evaporation from the soil due to the absence of the sun's heat." (*Quarterly Journal*, Royal Meteorological Society, XV, 1889, 132).

There appear to be certain misconceptions in this statement, which we would venture, with all respect to their distinguished author, to point out.

It is implied and stated that there is an "increased temperature at night in the higher atmosphere;" but observations at mountain observatories by no means bear this out. It is true that the diurnal range of temperature decreases as we ascend in the atmosphere, especially in clear, anti-cyclonic weather, to which Dr. Marcet's remarks refer; and in accordance with this, the temperature of the air near the ground may fall to a lower temperature than that above it. The reason for the greater temperature range near the ground is manifestly to be found in the superior radiating power of solids over gases; gases are slow in changing their temperature by radiation; solids, especially poor conductors like rock, soil, vegetation and snow, are quick to cool on the surface by radiation; and the air near them cools then by conduction to them. The greater dustiness of the lower air is probably an important aid to the same end; for every dust particle serves as an efficient center of radiation at night, continually throwing off the heat that it acquires by conduction from the air near it. The good thermometric conductivity of the air is also an important element in the process; for however poor a calorimetric conductor it may be, we are concerned in meteorology chiefly with its power to change its own temper-

ature by conduction; that is, its thermometric conductivity, and it must not be forgotten that in this respect it is more active than iron and almost as active as copper.

Again, when the lower air is once cooled below the temperature that determines instability, it loses the continual convectional motion that characterizes day-time, and becomes relatively calm; thus the cooling of the lower strata is cumulative, unlike the warming of the surface strata in the day. It is this absence of convectional interchanging currents that is in greatest part responsible for the superior clearness of nights; this also being an anti-cyclonic condition, for cyclonic areas are probably more cloudy by night than by day. Cumulus clouds, which are the prevailing clouds of the sunshine hours, are essentially a product of local convectional currents, having their maximum in warm regions, warm seasons and warm hours; they disappear about sunset, not because of "the increased temperature at night in the higher atmosphere," but because the condition of their maintenance, namely, ascending currents of air then, fails. This is best seen in tropical countries, where cyclonic complications are rare.

Dr. Marcet is also, we believe, in error, in stating that the heat radiated from the earth at night "rises through the air until it comes into contact with moisture," etc. Apart from the objectionable terminology here employed, the passage is open to criticism in implying that nocturnal radiation from the earth is largely absorbed in the atmosphere, and that the upper air is thereby warmed. As long as a stratum of cloud exists, absorption is probably in excess of transmission; but in settled weather, when the inversions of temperature here considered occur, the clouds disappear soon after sunset, and radiation through the atmosphere to outer space goes on little impeded from that time till morning. It is true that when the air is relatively moist, a larger share of radiation from the ground is absorbed than when it is relatively dry; but at times of most distinct inversions of temperature, namely in winter anti-cyclones, the air is unusually dry; except close to the ground, and there its dampness is not a result of an increase of vapor, but comes from the very fall of

temperature under discussion. Certainly, as far as terrestrial radiation is concerned in warming the air above the earth, it is much more effective in the day time, when radiation is most intense and when the greater cloudiness of the air increases its power of absorption; and less effective at night, when radiation is weak and the day is relatively clear. The essential answer to the question as to what becomes of the heat radiated from the earth at night is that it passes through the atmosphere and is "lost" in outer space. W. M. D.

Rainfall on the Plains.—Prof. Frank H. Snow, of the Kansas State University, said several years ago: "But the fact that thousands of new-comers, from ignorance of the climate, have attempted to introduce ordinary agricultural operations upon the so-called plains, and have disastrously failed in the attempt, has placed an undeserved stigma upon the good name of Kansas in many far-distant communities, and has undoubtedly somewhat retarded immigration during the past few years. It is time for the general recognition of the fact that, except in the exceedingly limited area where irrigation is possible, the western third of Kansas is beyond the limit of successful agriculture." The severe seasons of drought which have occurred since the above conservative statement was written show the whole truth of the matter to be that the westward advancing line of settlement is by no means an isohyetal one, but that it is merely a line representing in a way the overflow of the population of our Eastern States. It needs but a slight acquaintance among the old settlers in central Kansas to know that they fear nowadays excessively dry weather as much as they did twenty-five years ago. The people who live further west are losing faith in the idea of an increased rainfall, as is evidenced by the fact that over two hundred linear miles of main canals have lately been constructed for irrigation purposes nearly as far east as Kinsley, in the Arkansas Valley of western Kansas. In the Platte Valley, in Nebraska, large irrigating systems are at present being projected.—Stuart O. Henry, *in the Popular Science Monthly for February.*

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